UNDER THE BEAUFORT

Canada Drills in the Arctic

Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

©Published under the authority of
John C. Munro, M.P. P.C.
Minister of Indian Affairs
and Northern Development
Ottawa, 1980.
QS-8249-000-EE-A1
Catalogue No. R72-159/1980 E
ISBN 0-662-10913-9
Design: Gregory Gregory Limited

Cette publication peut aussi être
obtenue en français

The Dene called it Deh-cho, the Big River. The Mackenzie is the longest river system in Canada, its drainage basin encompassing nearly one-fifth of our country. Its complete length is navigable.

A MAN AND A RIVER

Alexander Mackenzie was not having one of his better days as he pushed his bark canoe expedition down the broad flow of the river that was to bear his name.

It was early morning July 24, 1789, when the famous explorer, unhappy about not finding the Great Western Sea, paused to examine a slate-like formation where Indians gathered flint.

"Amongst the small stones were. . . .petroleum like pieces of yellow wax but more friable," he jotted in his journal.

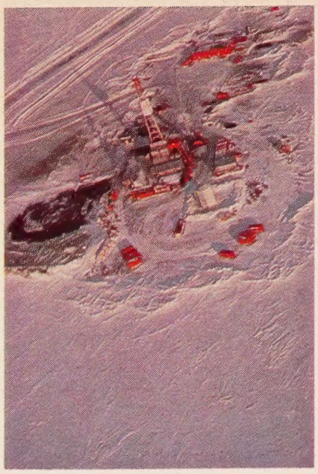
More attention was not warranted. The dour young Scot was seeking the riches of furs not petroleum, which had little or no worth.

Many decades would pass before people realized that Mackenzie had been the first white man to discover oil in the Arctic.

Paddling the northernmost reaches of his river today, Mackenzie would find stretches of wilderness still virtually untouched. But approaching the Beaufort Sea, where the broad river tires and unloads its rich silt on the Mackenzie Delta, he would be awestruck.

Extensive seismic exploration to chart the geology of the area preceded drilling in the Arctic waters.

Exploratory drilling from artificial islands was sufficiently promising to warrant further work in deeper water from drillships.



Canadians have been learning energy lessons the hard way recently. Soaring home heating bills, higher prices for myriad petroleum-related goods, the spectre of gas pump lineups and the $1-plus gasoline gallon hammer home the same point.

There is a bottom to the bottomless petroleum pit.

We are learning to conserve. But we know that we must find fresh energy supplies to free our living standards from the vagaries of far-off foreign oil.

The challenge in the Northwest Territories' Beaufort-Delta region is to develop new oil and gas supplies for Canadians, and to do this with minimum disruption to the lives of northerners and to the special Arctic environment.

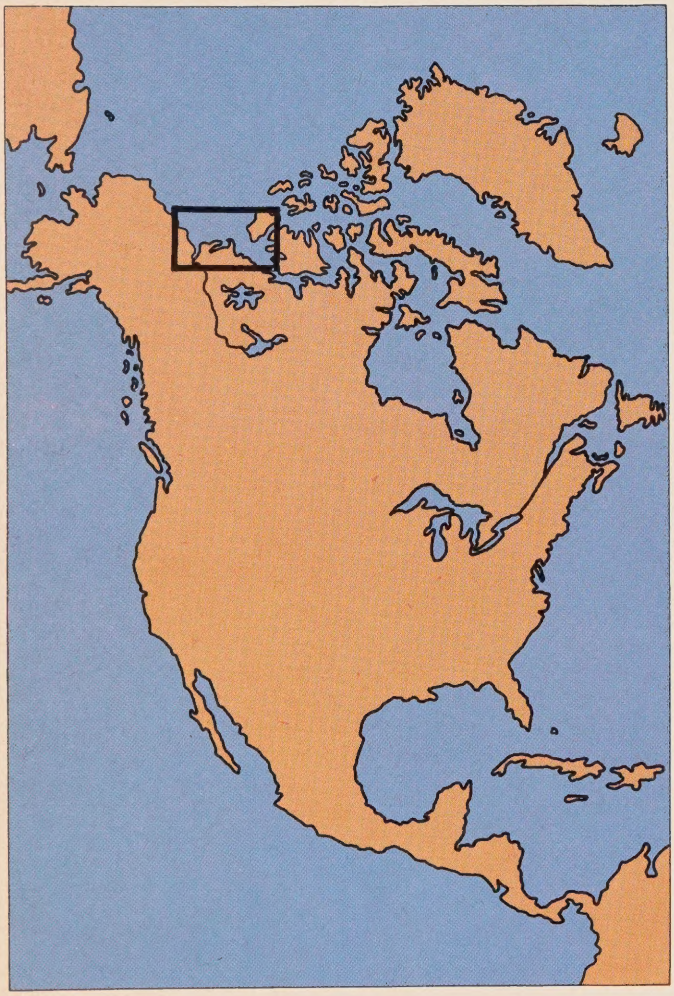
Giant mechanical dragonflies, ferrying modern explorers chatter loudly as they wing erratically over the cold grey sea. Gravel islands, created by men to hold drilling rigs, dot the shallows close to land. Ships, burdened with supplies for offshore drilling crews, steam hard for the north horizon.

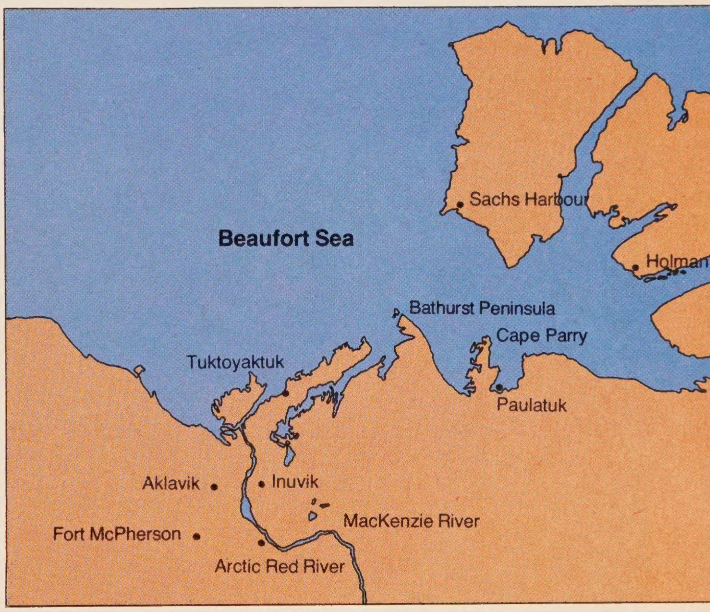
"A grand fuss over a chilly little sea," Mackenzie might be tempted to mutter.

Today, some Canadians also are wondering about the fuss. There are genuine concerns about exploration and drilling on the Beaufort and the surrounding Delta region. Many questions are being asked about the presence of the resource explorers.

Answers are, at the same time, simple and complex.

Basically, the drill rigs are there to help ensure the future of Canada. They are part of the important drive to make this country more energy self-sufficient before the turn of the century.




Beaufort Sea
Sachs Harbour
Holman
Bathurst Peninsula
Cape Parry
Tuktoyaktuk
Paulatuk
Aklavik
Inuvik
MacKenzie River
Fort McPherson
Arctic Red River

Canmar's drillships were specially modified in Canadian shipyards for operations in Arctic waters.

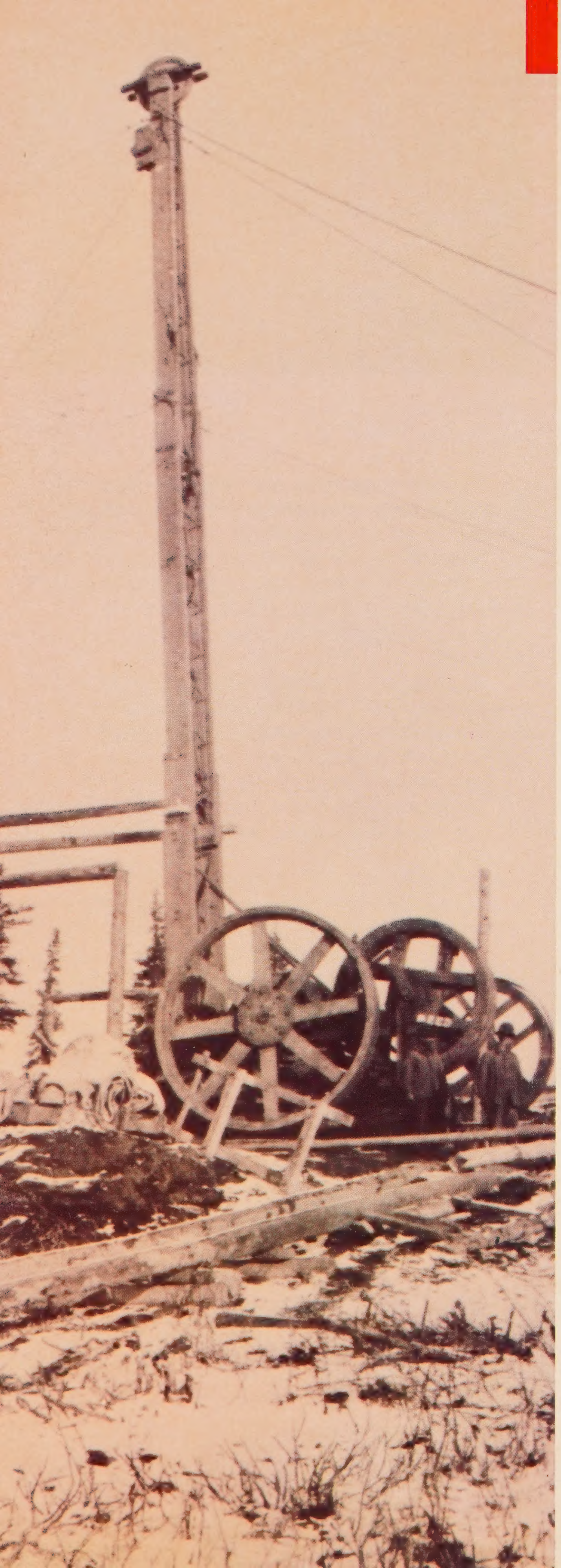
History

Several explorers, starting with Alexander Mackenzie, noticed the presence of probable petroleum-bearing formations in the Northwest Territories.

But none made a more prophetic report than Robert G. McConnell, a member of the 1887-88 Geological Survey of Canada.

In his report to the federal government McConnell wrote:

"The possible oil country along the Mackenzie Valley is seen to be almost co-extensive with that of the valley itself. Its remoteness from the present centres of population, and its situation north of the still-unworked Athabasca and Peace River oil field will probably delay its development for some years to come, but this is only a question of time. The oil fields of Pennsylvania and at Baku already show signs of exhaustion, and as they decline the oil fields of northern Canada will have a corresponding rise in value."



RAISING THE ICE CURTAIN

A succession of explorers, traders and geographers followed Mackenzie's paddle strokes down to the Beaufort Sea. Some, notably Robert G. McConnell of the 1887-88 Geological Survey of Canada, also noticed the presence of oil.

But it wasn't until 1919, roughly 21 years after the first gasoline-powered automobile was sold in Canada, that the Northwest Company — a distant forerunner of Imperial Oil Ltd. — began drilling in the river valley. It struck oil at Norman Wells, N.W.T., not far from where Mackenzie found his yellow wax.

The vast land mass north of the 60th parallel had its first oil well.

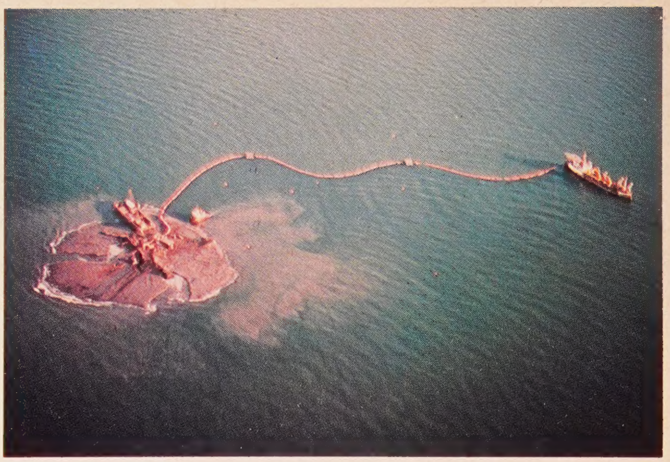
A 500 million barrel capacity oil field has been functioning since 1932 at Norman Wells, about 1,450 kilometres northwest of Edmonton, to supply the northern market.

Norman Wells, however, was not to be the immediate start of something big in the Northwest Territories. The discovery was then commercially insignificant. The land was too remote. The climate was too harsh. Oilmen were concentrating on southern fields such as Alberta's Turner Valley.

Also the oil companies could not simply move in to drill the North. All surface and mineral rights in the Northwest Territories and Yukon were, and still are, owned by the federal government.

Extreme northern location means that all supplies and materials must be brought in from the south.

Artificial islands, formed of material dredged from the sea floor, become drilling platforms in shallow Beaufort Sea waters. After the well is completed and sealed off, the islands are allowed to wash away.



The government did allow exploration, on the condition that the companies spend so much money per acre on annual exploration.

The first large filing for exploration permits was in 1958. However, activity tapered off as many large companies later felt that the geology was not promising and surrendered their permits/exploration rights.

Then early in 1968 British Petroleum Ltd. and Atlantic Richfield Co. flashed an announcement that would make the name Prudhoe Bay a virtual household word.

The Alyeska Pipeline brings crude oil from Prudhoe Bay south across Alaska to the port of Valdez where it is shipped by tanker to the U.S. west coast.

By that summer it was apparent that the companies had hit and hit big, at Prudhoe on Alaska's North Slope bordering the Beaufort Sea.

All eyes were rivetted on the North. By the end of 1969, nearly 400 million acres of the Northwest Territories' mainland, Arctic Islands and offshore waters were under permit for oil and gas exploration.

In 10 years this had been reduced to 180 million acres as the companies zeroed in on promising areas, notably the Beaufort Sea and Delta region.

The last large public sale of permits was in January, 1969. Several large companies then acquired oil and gas rights on the condition that work bonds deposited with the federal government be spent on exploration work over the following six years.

In 1976 the government had encouraged exploration in remote areas providing a special frontier tax allowance as well as the various incentives in the Canada Oil and Gas Land Regulations.

These tax incentives have resulted in almost $1 billion being invested in Beaufort Sea-Mackenzie Delta exploration.

PERSERVER-ANCE PAYS OFF

Imperial Oil came up with another first in 1970 when it struck oil at Atkinson Point, near the Delta village of Tuktoyaktuk. Other discoveries followed.

Attention shifted to the waters beyond the land, however. The industry soon confirmed its earlier suspicion that three-quarters of the most interesting potential oil-bearing ground lay under the Beaufort Sea.

Imperial executives went to Ottawa and asked permission to begin drilling the Beaufort seabed. The Indian and Northern Affairs Department, with the Arctic Waters Pollution Prevention Act at its disposal, granted permission to drill from artificial islands in 1972.

For the first time in Canadian history, the oil rigs were moving into Arctic waters. The question now was how to drill.

Beaufort Sea offshore operations are carried out under the toughest regulatory conditions placed on exploration and drilling anywhere in the world.

Ten exploratory wells have been successfully drilled and sealed in the Beaufort Sea from drillships since 1976.

Esso Isserk E-27 artificial island was built in 12.8 metres of water. The well was drilled to a depth of 4180.6 metres and abandoned after an expenditure of $43 million.

Drillships could be used, or rigs could be placed on reinforced ice platforms or on artificial islands. Imperial opted for building islands in the shallow waters close to land. The first islands were built in water a metre or so deep, but one recently has been constructed in 20 metres of water.

Construction involved dredging and dumping huge quantities of fill. A mere 180,000 cubic metres of fill was used on the first island, compared with 3.5 million cubic metres for the one in the 20-metre depth.

Artificial islands had been built before in other parts of the world, but never for oil drilling.

Work on the first island, Immerk, began in 1972. On September 17, 1973, a drill rig began the first exploration hole in the Beaufort Sea.

The following spring, Imperial began another island, Adgo F-28. Drilling began January 24, 1974 and gas and oil showed at the 2,100 metre level.

Almost 185 years after a disappointed Alexander Mackenzie had gazed across its ice-strewn surface, the Beaufort had given up the first of its hydrocarbons.

Roughly 165 holes have been drilled both on and offshore in the Beaufort and Delta region. Some have shown oil and natural gas. Atkinson Point, for instance, has a potential of 2,000 barrels of oil a day.

Currently none of the Delta or Beaufort holes are production wells. They are simply exploratory wells that help the oilmen map, calculate and analyse how much petroleum and what kinds, exist in the region.

All these exploratory wells were abandoned or suspended. Whatever gas and oil they contained would sit and wait for technology and future decisions to get them to market.

SAILORS WITH HARDHATS

Sailors with Hardhats

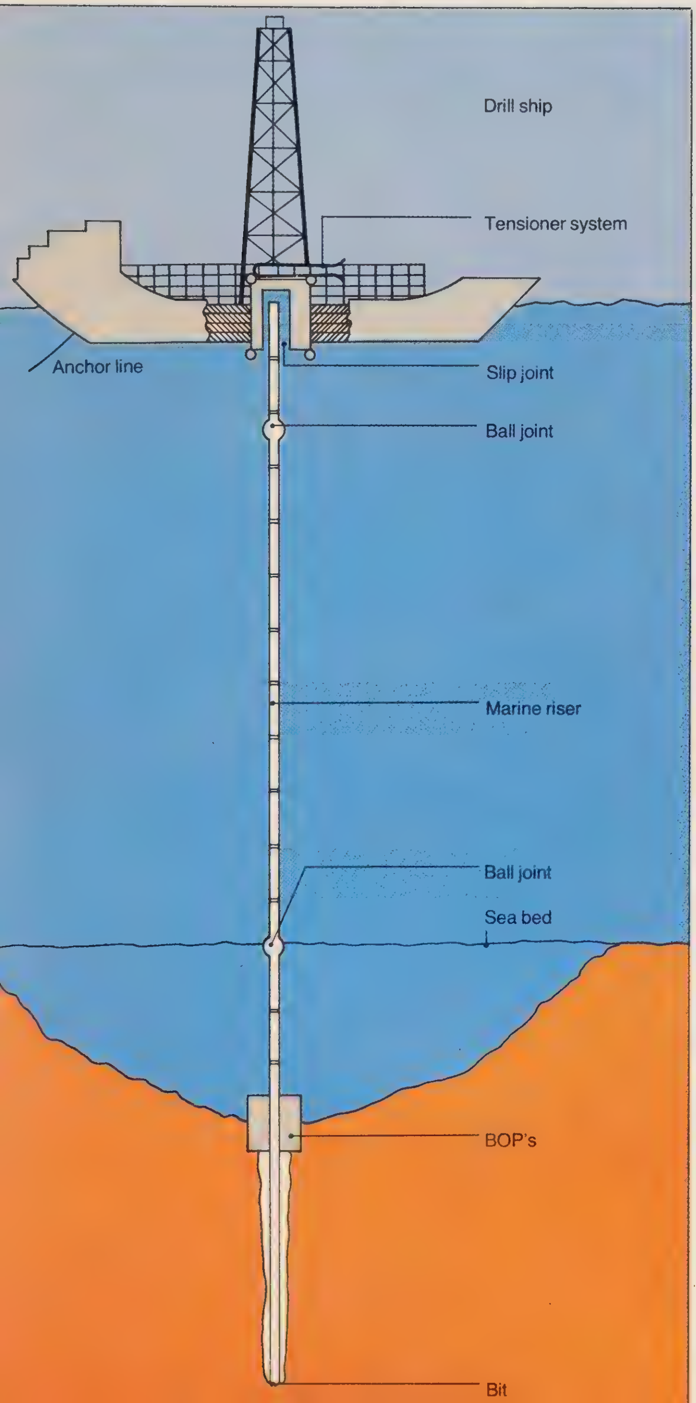
It's summer, 1976, on the Beaufort Sea. The relatively warm air of the all-too-brief interlude between one winter and the next has rotted and dispersed the shorefast ice. Large stretches of sparkling water have appeared, opening a playground for the millions of waterfowl ending the exhausting journey from the south.

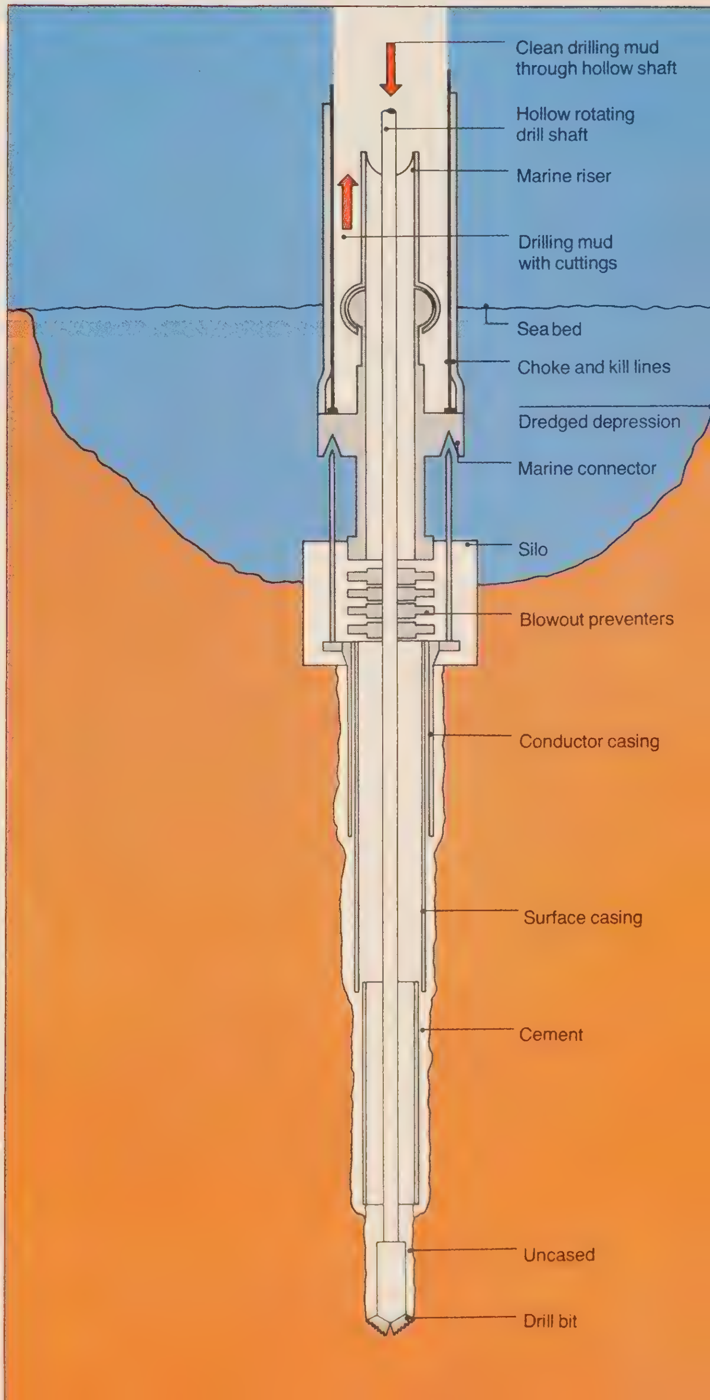
Far out from shore, the immense polar ice pack is retreating, loosening its vicious grip for a few precious months. The freed seas, dancing in brilliant sunlight, accommodate large ships that steam lazily across the surface, then drop anchor.

The ships, bearing the marks of Canadian Marine Drilling (Canmar), are unusual. The crew members wear hardhats. Amidships are tall steel derricks, which at first glance, seem capable of turning the carriers topside down during the slightest swell.

They are drillships come to begin a new era in the Beaufort Sea drilling story. They are to open a whole new world of technological challenges in a sea that is hardly ever free from hard-to-predict movements of the polar ice pack.

Divers check wellhead equipment on the Beaufort Sea floor.





"Roughnecks" crewing the rigs in the north have extensive experience gained drilling for oil in Alberta and abroad.

The petroleum industry had waited four years for federal permission to use drillships. The government, concerned about environmental risks in this unprecedented Arctic venture, had withheld permission while environmental studies were carried out. During this time new and more stringent regulations were being written for drillship operations.

There were many potential difficulties to be considered. But to the average layman, the first question was: How can anyone drill the sea floor from a bobbing ship?

The answer is that the ship is not anchored in ordinary fashion. Eight mammoth anchors, weighing 14,000 kilograms each, circle the drill ship. Steel cable anchor lines, as thick as a man's wrist, secure the ship to the weights.

The ship remains free to bob or roll, but not violently.

Below the derrick is a large square hole through the centre of the ship called the "moonpool". It's like having your own natural swimming pool aboard, except the bottom is actually the sea floor. Drilling is done through this cut-away section, which is large enough to allow the drilling assembly clearance when the ship does pitch or roll.

A well is started by dredging a large depression in the sea floor. This "glory hole" will house wellhead equipment, including a blowout preventer. It is deep enough to prevent keels of ice, which might scour the sea floor, from colliding with the head of the well.

Drilling begins with the boring of a shaft, perhaps close to one metre in diameter, in the centre of the glory hole. The initial shaft might go down 150 metres. A smaller diameter pipe is put into the shaft and is encased in cement. This casing reduces the diameter of the hole, so that when drilling resumes a smaller bit is used. The deeper the hole goes, the more casing is run in the hole and through telescoping, the smaller the drill hole becomes.

In the submerged glory hole, atop the casing, sits the blowout preventer. It is a giant valve, designed to shut off a sudden, violent rush of oil or gas. A sudden rush of oil that was not shut off could spread uncontrolled into the sea.

Canmar's 1976 drilling was regarded as a controlled experiment. Government officials monitored the operation and a report on that first season was presented to the federal cabinet.

The following year, cabinet authorized Canmar to drill for three more seasons.

Inuit hunters are hired to protect the crews on artificial islands from polar bears.

Attached to the drilling authority were stringent technical, environmental and socio-economic terms and conditions. Government inspectors monitored the Company's application of those terms and conditions to its operations and each year reviewed and published reports.

There have been no oil blowouts, major accidents or major environmental problems. By the end of the 1979 season, ten wells had been drilled successfully, the deepest to more than 5,000 metres, in waters as deep as 60 metres.

Experience gained by the government and the company through the monitoring process and adaptation of new techniques has allowed the drilling program to be extended. The deep drilling season, which starts when the ice retreats in June or July and ends in late September or early October has been extended safely from the initial 11 to 16-17 weeks.

Some shallow drilling operations have extended to the end of November.

The Beaufort Sea is completely free of ice only two months of the year.

Ice

Ice is king of the Beaufort Sea and it dictates when drilling will be done.

There are three main zones of ice in the Beaufort.

1 Shorefast ice can extend out to the seven-metre depth, and sometimes even to areas where the water is as deep as 20 metres. These depths may be as far as 15 to 40 kilometres from shore.

2 The area between the shorefast ice and the polar ice pack is called the shear zone. It is in this zone that the drillships are operating. The shear zone is characterized by ice on the move. Winds and currents push the ice - generally east to west - throughout most of the year.

3 Beyond the shear zone is the polar ice pack, which never melts. The pack rotates slowly around on the north pole and its behaviour depends heavily on wind conditions. In some years the polar pack may be 500 kilometres from shore. In others, it might come close as 15 to 40 kilometres, right up to the shorefast ice.

Chunks often break off the polar pack and float into the shear zone. They are so thick that they don't melt in summer, and they can have deep keels capable of scouring the sea bottom in shallow waters.

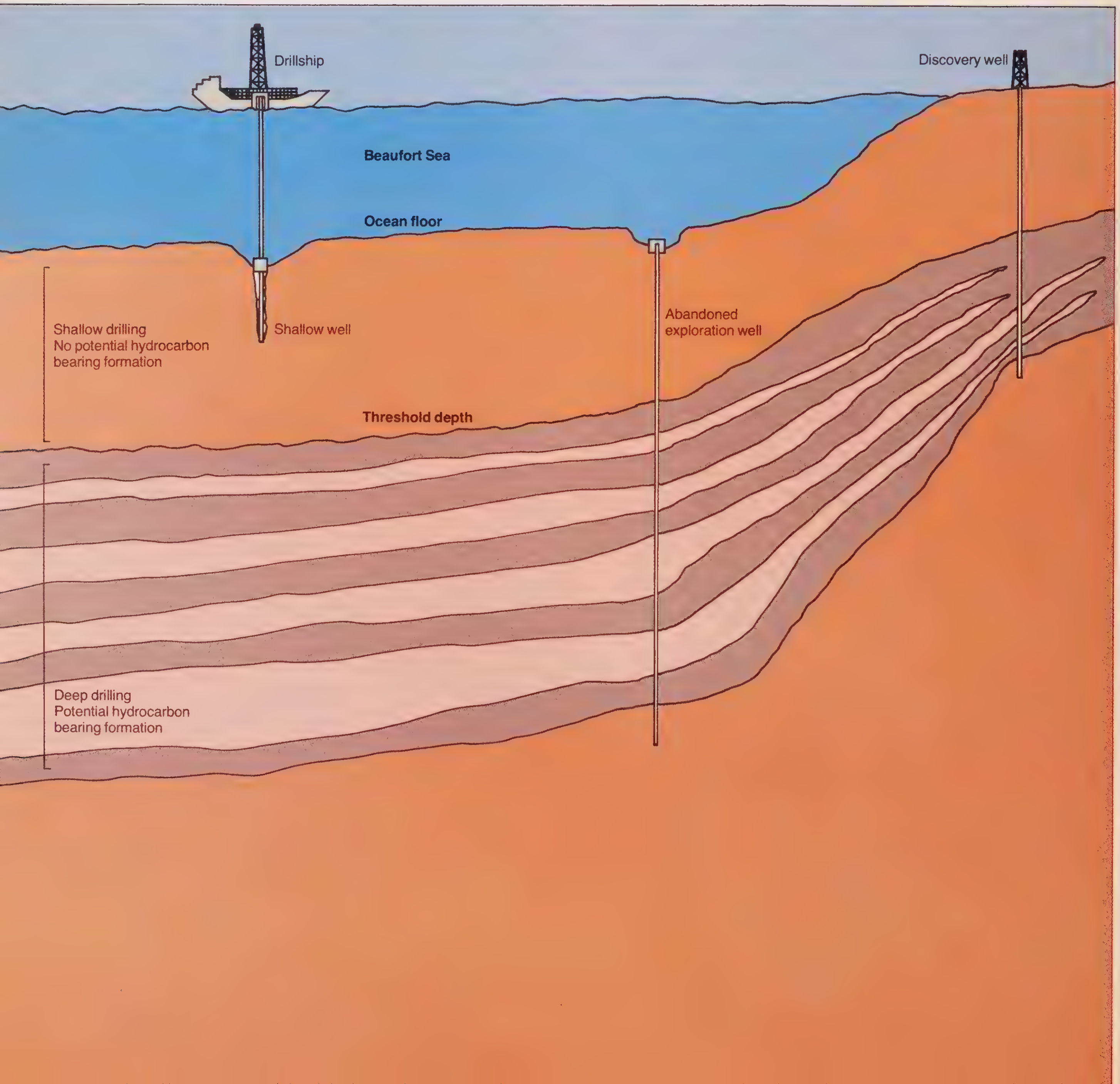
The behavior of these keels is being studied because of the danger they might pose to wellhead equipment, or to any future pipelines laid along the Beaufort floor.

Moving ice is tenacious and can force a drillship off its borehole. It has enough force to snap the 75-millimetre thick anchor lines that hold the ships in place.

This happened in 1978 and Canmar had to adopt new procedures for shutting off wells and moving ships out quickly.

An ice-tracking system tells the company when ice might be moving in quickly.

The Beaufort Sea is rich in marine mammal life like these Beluga Whales.



BLUEPRINTS FOR PROTECTION

Blueprints for Protection
When the oilmen began moving north, it was clear that their work presented a risk to the Arctic and its people. Not only was the land delicate, it was relatively unknown and not intensely explored.

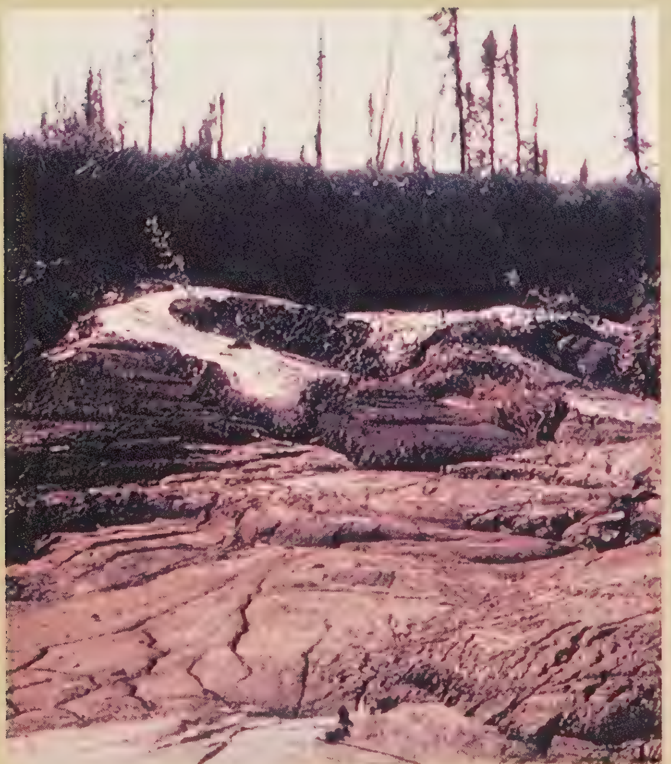
Much of the land contains permafrost - a permanently frozen mixture of soil, rock and ice. In summer, the thin top layer will thaw but the ground below remains frozen, leaving no subsurface drainage for water. A tracked vehicle driven across a thawed area, therefore, will leave ditch-like water-filled scars for years to come.

Seismic crews, drilling rigs and other modern intrusions might upset the fragile life chain of the birds, mammals and fish. And, of course, how would the advent of southern life-styles affect the lives of the native people?

The Beaufort itself presented other environmental difficulties. A blowout might spew oil into the sea endangering the sea life and the waterfowl that inhabit the waters.

What would happen if pack ice, or a severe storm, forced a drill ship off its drilling location when oil was present? What about the dangers of spills of oil, fuels, chemicals or wastes from the drill ships?

When the insulating layer of earth and vegetation is removed or disturbed, the underlying permafrost thaws to a muddy consistency and flows away. The damage is permanent and long-lasting.



Geology

The Arctic is different in many respects, but probably most noticeably in its geology.

Three geological phenomena, not found in other parts of Canada, have been encountered in the far North. Each has posed a special problem that has demanded more sophisticated drilling techniques.

1 *Undersea permafrost*: When the Beaufort Sea drilling began it was not known that permafrost existed under the sea bed. The ocean does not freeze solid, so it seemed unlikely that the ground below would be permanently frozen.

Drilling soon revealed, however, stretches of discontinuous permafrost from two to 60 metres deep.

The immediate problem created by permafrost comes from the use of cement in bonding the casing to the outsides of boreholes. The chemical reaction in setting cement throws off a slight heat capable of thawing the permafrost and preventing the bonding of the casing to the bore hole. This makes the hole unstable.

2 *Hydrates*: Gas in frozen water lattices are called hydrates. They can exist in frozen or non-frozen formations, but heat from warm drilling muds can cause them to decompose and become gaseous. Gas contained within the ice lattice is under original formation pressures, and thus compressed. With decomposition it expands, diluting the mud and releasing volumes of gas into areas of the drilling system not designed to handle gas or pressure.

Both of the above problems have been solved by using chilled drilling mud with a refrigerated conductor casing.

The government, conscious of the many risks involved in exploration, had to move on all these questions to ensure protection of the environment and the people.

Since 1971, oil and gas seismic and drilling operations on land, including artificial islands, have been subject to the Territorial Land Use Regulations. The Regulations are administered through a system of Land Use Permits, each setting out the environmental terms and conditions under which the operations must be conducted. The permits specify the timing of various activities, equipment to be used, exact areas to be covered, avoidance of critical wildlife habitat and pollution prevention measures to be taken at camp and work sites.

The regulations were extended in 1976 to ensure that all operations, large or small, that might affect the environment be covered by permits. Also, conditions listed in the permits are set out only after consultation with northern communities which might be affected by the work.

Combined with these controlling regulations are those under the Northern Inland Waters Act and the Arctic Waters Pollution Prevention Act. The latter took effect in 1972.

The polar ice pack can trap and shatter ships not built for arctic conditions.

Technically, too, it was necessary for the government to control operations that held the potential for serious damages to resources and persons. The Oil and Gas Production and Conservation Act was passed in 1968-69, allowing the government to draw regulations covering drilling, geophysical work, production, conservation, transportation and processing of oil and gas on land and offshore areas north of 60. This new authority overtook the older and less stringent Canada Oil and Gas Drilling Production Regulations promulgated in 1961.

This Act has become the main instrument for government control of oil and gas exploration activities in the North.

During the four years that the government held up shipbased drilling permission in the Beaufort Sea, $12 million was spent on intensive environmental studies - $4.1 million by industry and $7.9 million by Ottawa.

Before permission for the 1976 experimental season was given the government asked that the companies develop five innovative systems aimed at making drillship work less risky and for this Dome-Canmar received a $4 million federal grant under an industrial technology advancement program.

The systems are:

1 A quick disconnect system that would allow a drillship to close off its borehole and leave safely if the ice pack or a severe storm approached suddenly.

2 A system for tracking ice movements.

3 A water jet thruster to push ice off its planned course.

4 A controlled explosion system for breaking ice.

5 A caisson to protect sea floor drilling equipment against an ice keel that might be deep enough to enter the glory hole.

The drilling conditions placed on Canmar in 1976 specified high safety standards for equipment, systematic equipment testing, personnel training, round-the-clock government inspection, and stringent standards for drilling. They have been called, with some justification, the toughest conditions placed on exploration and drilling anywhere in the world.

The reasons are obvious, once you understand the geography and ecology of the Beaufort Sea and the Mackenzie River Delta.

The Beaufort, one of the seven seas of the Arctic Ocean, is mainly ice-choked for six to eight months a year. Oil from a spill in the brief spring or fall would congregate and become trapped in leads between the ice.

Polar Bears den along the Beaufort Sea shoreline and hunt on its ice.

So might the birds, seals, whales and polar bears that cling to the Beaufort for life.

Or, a storm might carry the oil inland to the Delta's marshes, where millions of birds and fish feed and breed.

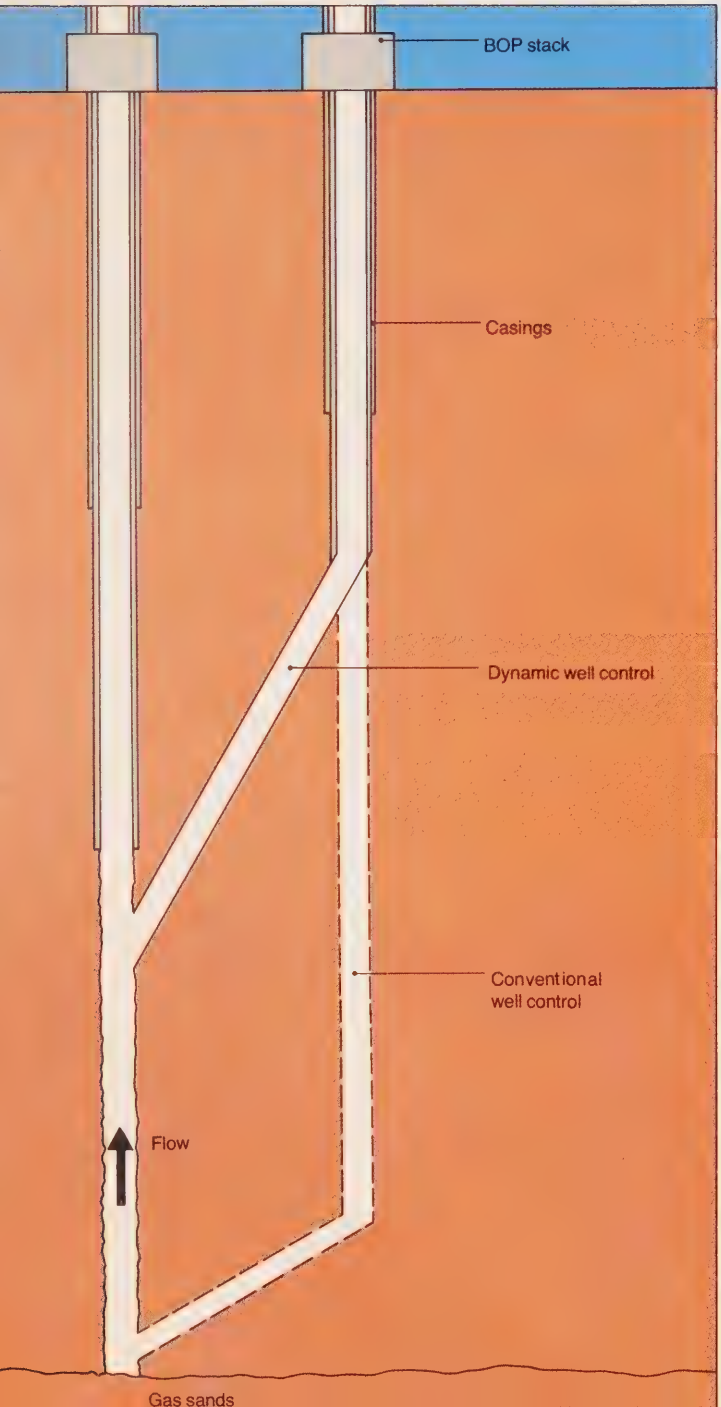
Life in the Delta is complex. The Delta is a series of channels, islands, lakes and marshes all at, or close to, sea level. It is a series of huge sponges from which wildlife sucks nourishment.

Oil spill damage to the Delta might not be irreversible, but recovery might take up to 10 years.

World experience indicates that the chances of any kind of blowout (water, gas, oil or a combination) is in the range of one in 1,000. The probability of a blowout with a significant amount of oil is correspondingly less. The chance that 500 barrels will be spilled is one in ten thousand.

The environmental consequences of a natural gas blowout would not be as severe because most of the gas would escape into the atmosphere and dissipate. However, the chance is there and the government had to do everything it could to lower the risks.

"Same season relief well capability"
using dynamic well control



The polar ice pack often is unpredictable and almost always immensely powerful. Pressures and weight of ice buildup can shatter the vehicles of men like balsa toys.

This is why the government has placed strict limits on the timing of the Beaufort Sea petroleum resource search. Startup and shutdown dates are carefully established.

The shut down date for drilling any well at depths where oil and significant amounts of gas may be encountered is calculated to ensure a complete safety margin against a last-minute uncontrolled blowout of oil or gas. Where other methods fail a blowout is brought under control by drilling a relief well directionally into or very near to the uncontrolled well bore and flooding it to bring the blowout under control. The date for the end of the season is calculated to enable such a relief well to be drilled even if a blowout should occur on the last day of work for deep well operations. This is known as "same season relief well capability". The Government approved Canmar's drilling program for 1979 with the condition that all deep-well drilling terminate on September 25 with the provision for an extension in favourable weather and ice conditions, and provided there was same-season relief well capability.

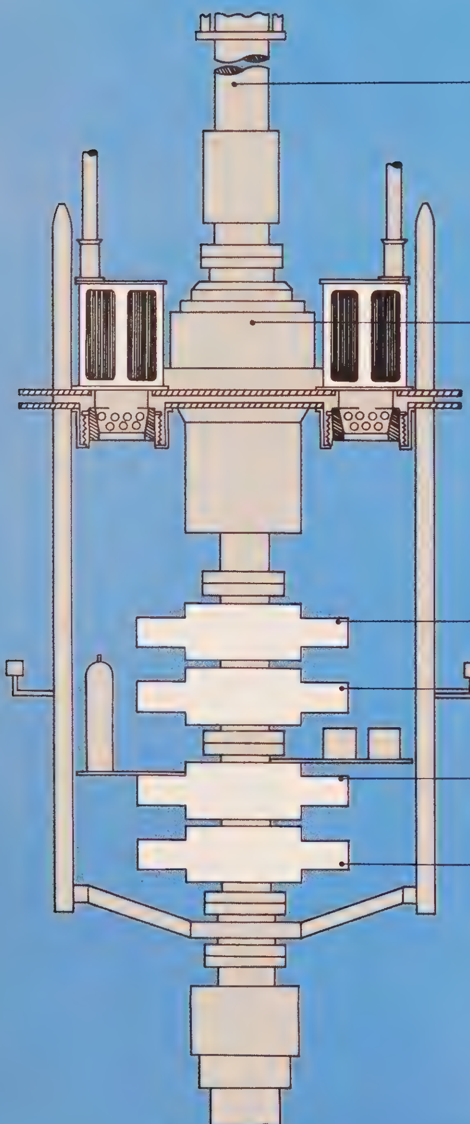
The effect of "scouring" of the seabed by ice was thoroughly investigated before offshore drilling was authorized.

After the September 25 deadline, the Company is allowed to drill "shallow wells" to levels above the risk threshold depth. The length of time the Company can drill shallow wells depends in part on the capabilities of the drillship and the judgement of its master and ice breaker assistance up to December 31 when navigation ends.

Drillships must be attended by ice breakers if ice conditions are severe. One Arctic Class 2 breaker, capable of smashing .6 metres of ice, must be present from September 25 to the time that new grey-white ice forms. That ice usually is 152 to 203 millimetres thick.

Two Class 2 breakers must be present from the time of grey-white ice formation. At least a two Class 2, and not less than a one Class 3 (which can navigate in one metre of ice) breaker should be present after December 5 to December 31.

Typical arrangement for subsea BOP stack controlled from above.



Blowout

Everyone has seen movies in which drillers strike a gusher that sends oil roaring toward the sky. This never happens any more.

Through carelessness or accident, drillers may lose control and a blowout may occur. Blowouts are shut off with a large piece of wellhead equipment called a blowout preventer.

In drilling, zones of high pressure sometimes are entered. The drillers put heavy materials in their drilling fluid, or 'mud', down the borehole to balance the pressures that might force oil or gas to shoot up the hole.

If the weight of the mud is not enough to balance the pressure, a 'kick' might occur. This is a flow of pressurized gas or oil into the bore.

The blowout preventer, which involves a series of hydraulically-operated valves, can be used to choke the 'kick' and prevent the oil or gas from spewing out of control.

In the Beaufort, the blowout preventer sits atop the wellhead in a glory hole. The glory hole is a large depression dredged into the sea floor. It is deep enough to prevent keels of ice from colliding with the wellhead.

THE WATCHERS

Two types of government inspectors frequent the Canmar drillships — engineering and environmental. They regularly check to ensure adherence to the environmental and technical terms and conditions.

The drillers are bound to keep pollution from their ships to a minimum. They also must post a $60 million security to cover the costs of any oil spill disaster and must be involved in the contingency plan to contain and clean up any spill.

Industry and government have directed considerable energies toward preventing spills. But should one occur, the contingency plan, involving all major operators there is ready to be put into action. The government has contingency plans that can be activated to back up the industry and take charge of the overall cleanup effort if necessary.

A simulated oil spill has been carried out to learn more about the behaviour of oil in the Beaufort Sea's special conditions.

Environmental inspectors also watch over seemingly minor related activity. They keep close tabs not only on the drillships but on accompanying supply vessels, barges, icebreakers and other machinery used in the search.

They study substances used in drilling fluids, analyse effluent from ships and check every minor spillage of oil. Some of the drilling fluids, muds used to lessen friction and to keep pressure on the hole, could be lethal to Arctic waters, plant and animal life.

The inspectors check to ensure the drillers treat or remove pollutants from the fluids, or that they dilute them before jettisoning them. Still, small quantities of toxic materials might be released into the sea, and work is under way to perfect the treatment processes.

In their attempts to determine the best way of disposing of oil that might be spilled on ice-infested water, environmentalists have experimented with various ways of burning it off.

Contingency plans are in place for cleanup in the eventuality of an oil spill.

Contingency

The chances of a blowout are slim, but if one did occur there is a complex contingency plan ready to meet the danger and to clean up any oil spill.

The plan, which would be put into action by the deputy commissioner of the Northwest Territories, involves the entire oil industry and every level of government in the North.

Each unit in the contingency plan has a designated role and the plan is tested every year.

The capability of Canmar crews to carry out their share of the plan is assessed annually. All equipment, such as booms for corralling oil and skimmers, are checked to ensure they are in place and easily available.

This equipment is paid for by Canmar and must be kept within easy distance, usually within 30 minutes flying time from the drillships.

THE PEOPLE SPEAK

Before Canmar set its ships to sea, it went to the people — the people who for centuries have taken sustenance from the Beaufort and the Delta.

They are few, but it was known that southerners, with their different way of life, outlook and traditions, could have a tremendous impact on them.

Communities such as Tuktoyaktuk, Sachs Harbor, Holman and Paulatuk were isolated and generally insulated from the ways of the south. Many families continue the Inuit traditional life of trapping, hunting and fishing.

Canmar gathered in community representatives and funded the Beaufort Sea Community Advisory Committee. The committee, formed before the drillships arrived, plays a liaison role between the company and the communities.

Also, Dome-Canmar and the federal government signed a memorandum of understanding outlining a socio-economic program aimed at lessening the impact on northerners and maximizing the benefits to them.

There was, and still is, controversy over whether northern exploration and development improves or damages the lives of native northerners. The controversy can be found among the people themselves.

Petroleum exploration in the Beaufort Sea has introduced a new element to the traditional hunting and trapping lifestyle of Tuktoyaktuk, a nearby Inuit community. Many of its inhabitants have taken wage employment at the base camp and on the drillships.

Development-versus-people is an age-old debate that will not end tomorrow, next year or next decade. Meanwhile, the government and the company have put to work programs designed to make development more beneficial to the people.

Canmar gives job preference to northerners, uses local services and businesses as much as possible, maintains liquor-free camps and vessels, and regularly informs community councils of its plans.

Tuktoyaktuk, with a population of less than 1,000, is the sea-edge base for Beaufort drilling operations. Canmar keeps its southern employees in a separate camp outside the village.

The government conducts an annual socio-economic review of exploration effects on the communities. Reviews of the last few years have shown that many northerners have obtained work in the drilling program, are happy with it, and want it to continue. The northerners are gaining new skills that have helped them increase their purchasing power.

Trapping is winter work, so northerners have been able to retain that pursuit while earning industrial wages in summer. The average seasonal income for trapping in the region was $1,276 during 1978. This compares with average earnings of $6,300 among 181 oil industry workers.

In 1979, there were 110 local businesses participating in Canmar activities. The company spent nearly $17 million in the communities.

The Canmar base at Tuktoyaktuk is completely self-contained to lessen social impact to the nearby community.

Company activity comprised 15 per cent of all business activity in Tuktoyaktuk, five per cent in the Delta exploration capital of Inuvik. Add on government activity related to the drilling and the percentages rise to 40 at Tuktoyaktuk, and 15 at Inuvik.

Social impacts so far are considered negligible, except in Tuktoyaktuk. That community has seen a rise in social problems, especially those tied to alcohol abuse. Also, municipal services have been strained.

Family breakdowns have been evident but there is no evidence to link the social problems to the drilling program exclusively. Similar problems can be found in other N.W.T. communities.

In three communities, notably Tuktoyaktuk, there has been a small decline in the numbers of working trappers. However, overall, the Beaufort Sea communities have seen a slight increase in the amount of trapping.

A PROVEN GAMBLE?

Two words characterize the drilling business — expense and risk.

One exploratory well, commonly called a wildcat, can cost from $50,000 to $50 million in conventional situations. There's a one-in-10 chance of finding oil and gas, and the odds for hitting commercial quantities are even higher.

So far, the Arctic petroleum explorers have spent 10 years and billions of dollars drilling the Beaufort area, yet have not seen one drop of hydrocarbons go to market.

Oil has been discovered in 12 places in the Canadian Arctic, including one in the Beaufort Sea during 1979 and two fields in the Delta.

Natural gas exploration has been more successful. There have been eight Beaufort-Delta gas discoveries, and eight more in the Arctic Islands.

However, the estimated potential of the Beaufort Sea-Mackenzie Delta basin is 50 to 60 trillion cubic feet of natural gas and 30 to 40 billion barrels of oil. That is why the search goes on.

There has been plenty of talk about the technology and economic feasibility of bringing Arctic hydrocarbons south. Between 1974 and 1977 one of the most intensive inquiries in Canadian history, the Berger Inquiry, studied the possible effects of a gas pipeline along the Mackenzie Valley to bring Delta gas south. Central to the plan was a gas pipeline to bring Alaska gas to the Mackenzie Valley and the two streams south into Alberta.

Mr. Justice Thomas Berger of British Columbia, in a 481-page, two-volume report, recommended a 10-year moratorium on the pipeline.

In September 1977, Canada and the United States signed an agreement to allow construction of the Foothills natural gas pipeline from Alaska. This would run across the Yukon and down through Alberta to the lower 48 states. Construction of that line has been delayed.

The agreement also recognized the possibility of building a spur line along the Dempster Highway to the Mackenzie Delta. This route is considered an alternative to a Mackenzie Valley route for bringing the first Delta gas south sometime in the future.

How far off is that? No one knows. But the Beaufort-Delta search continues.

And, as it continues, there is considerable hope that the North will help achieve Canada's dream of energy self-sufficiency.

In the meantime, the millions of man hours and billions of dollars being spent have created a spinoff. The federal government and the oil industry are accumulating expertise and developing technology that is making Canada a world leader in the environmentally safe search for Arctic oil and gas.

Pollution

Four seasons of drilling from ships in the Beaufort Sea now have been completed without one major pollution incident.

There have been incidents involving environmental risks, but all have been minor.

On July 20, 1978, the Canmar drillship Explorer III was forced off its borehole by ice. This incident resulted in the federal government ordering Canmar to improve its ice alert system.

Two fuel spills from ships working on the Canmar project occurred.

A supply ship leaving Tuktoyaktuk harbor was damaged and lost 16,000 litres of diesel fuel along a 42-kilometre track. Diesel fuel is light and evaporates fairly quickly. No traces of it were found and there were no effects on the environment.

In November, 1978, the Canadian Coast Guard icebreaker John A. Macdonald which was supporting the operations at the end of the season was holed by an ice ridge and lost 240,000 litres of diesel fuel. Again, the fuel evaporated before it could be traced and the environmental damage was negligible.

A persistent technical drilling problem in the Beaufort Sea has been the fresh water-bearing shallow sands encountered just below the permafrost. The sands contain sufficient pressures to flow water to the surface unless the drilling mud is weighted. The balance between the formation pressures and the drilling mud column is such that, although the water flow is easily contained, circulation of the drilling fluid during further drilling tends to upset the balance of pressures, permitting water flows.

These water sands, once penetrated, are sealed off by casing and cement and pose no problems. However, the difficulty of maintaining the proper balance during penetration imposes a considerable time delay in the upper portions of the bore hole. These water sands do not appear to pose environmental risks as they contain a very limited amount of almost potable water trapped during the sedimentation process beneath the permafrost. Minor amounts of natural gas are also associated with the phenomena.

These sands were particularly troublesome in the Tingmiark K-91, Kopanoar D-14 and Kaglulik M-64 wells drilled in 1977 and 1978 but created no additional drilling problems in 1979.

GLOSSARY

Terms used in the Petroleum industry

Abandon
Term used when production is stopped from a well that is depleted and no longer capable of producing profitably. A well may also be abandoned after it has been determined that it will not produce.

Acidizing
Treatment of hydrocarbon - bearing carbonate or sand formations with a solution of hydrochlorine acid and other chemicals to increase production. The acid is forced under pressure into the formation where it enlarges the floor channels by dissolving the formation.

Barrel (bbl)
A unit of measurement in the petroleum industry, equivalent to 35 imperial gallons. The new metric standard is cubic metres and tonnes.

Blowout
Uncontrolled flow of gas, oil or other well fluids from a well during drilling due to formation pressure exceeding the pressure exerted by the column of drilling mud.

Blowout Preventer (BOP)
Hydraulically or mechanically operated high pressure valves installed at the wellhead to control pressure within the well.

Casing
Steel pipe threaded together and cemented into a well as drilling progresses to prevent the wall of the hole caving in during drilling. It also provides a means of extracting oil or gas if the well is productive.

Christmas tree
Valves, pipes and fittings assembled at the top of a completed well to control the flow of oil and gas.

Complete a Well
Finish the work on a well and bring it to a productive state. (Acidizing and fracing are examples of well completion processes).

Deep Well
Term used in the Beaufort Sea to signify drilling operations below formations known not to contain significant quantities of hydrocarbons. Drilling below the threshold depth is referred to as deep operations.

Derrick floor
The floor, or platforms, upon which the drilling crew works and the rotary table is located.

Development well
An oil well for oil and gas in a proven field or established area.

Drawworks
Hoisting mechanism which spools off or takes in the drilling line and thus raises or lowers the drill string and bit. (Essentially a large winch).

Drill Pipe
Steel pipe, in 30-foot lengths, screwed together to form a continuous pipe extending from the drilling rig to the drill bit at the bottom of the hold. Rotation of the drill pipe and the drill bit causes the bit to bore through the rock.

Drill stem test
Method of testing a formation to determine its potential productivity before installing production casing in a well. A testing tool is attached to the bottom of the drill pipe and placed opposite the formation to be tested. The formation is isolated by placing packers above and below the formation. Fluids in the formation are then allowed to flow up through the drill pipe, enabling measurement of the rate and volume of flow as well as sampling of fluids at the surface.

Drill string (or drilling string)
String of individual joints of pipe that extend from the Kelly to the bit. It carries the mud down to the bit and also rotates the bit.

Drilling fluid
Liquid, usually composed of clay and water, which is circulated through the well bore during rotary drilling. Rock cuttings from the bottom of the well bore are brought to the surface in the drilling fluid, which is also called "mud". The composition and pressure of the drilling fluid helps control downhole pressures. Drilling fluid also lubricates the bit.

Dry hole
Generally refers to any well that does not produce oil or gas in commercial quantities. Sometimes called a "duster".

Electric log chart
Chart showing the particular physical properties of rocks penetrated in the drilling of a well. The interpretation of the measurements indicate the top of each rock layer penetrated by the well, the presence of fluids, and other rock properties.

Exploratory well
Well drilled in unproven territory. Also called a wildcat.

Fault
Trapping of oil or gas may result in sealing of an oil bearing formation against a non-porous section.

Fishing
Procedure used to recover drill pipe that has broken and fallen into the hole.

Flow line
A pipe used for the gathering and transportation of oil from a wellhead or battery.

Fracturing (fracing)
Method of stimulating production by increasing the permeability of the producing formation. Under high pressure, a fluid (such as diesel fuel, crude oil, water) is pumped into the formation. The pressure causes cracks to open in the formation. Propping agents (such as sand grains, aluminium pellets) are carried in suspension by the fluid into the cracks. When pressure is released at the surface, the fracturing fluid returns, leaving the propping agent in the formation. The cracks partially close on the propping agent, providing channels for oil or gas to flow through toward the well bore.

Geophysical Exploration
Investigation of the subsurface including seismic operations, gravimeter, magnet — ometer, electrical, geochemical.

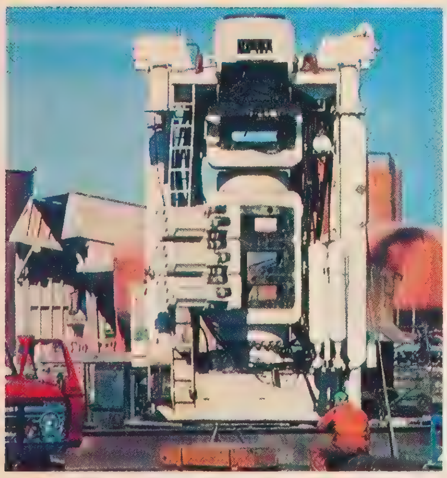
Glory Hole
An excavation in the seabed to a depth sufficient to put the blowout preventers below the sea floor.

Hydrocarbon
Organic chemical compound of hydrogen and carbon whose densities, boiling points and freezing points increase as their molecular weights increase. Both crude oil and natural gas are hydrocarbons.

Kelly
Square or hexagonal steel pipe 13.715 m (45 feet) long which transmits torque from the rotary table to the drilling string, thus rotating the string and bit.

Log
Systematic recording of data.(see electric log)

Lost Circulation
When drilling fluid which normally circulates from the top to the bottom of a drilling well escapes into a very porous or cavernous formation, it is said to be lost.



Making hole
Refers to progress being made at a given time when the bit is rotating and the well bore is being deepened. In other words, drilling - or drilling ahead.

Mud
Drilling fluid.

Multi-zone well
A well that may be used for the segregated production from, or segregated injection into, more than one zone through the same well.

Paying Quantity
The output of such quantity of oil or gas from a well as would commercially warrant the continued taking of such oil or gas.

Perforate
To pierce holes through casing into an oil or gas bearing formation by means of a perforating gun lowered into the well and fired electrically from the surface. The perforations permit oil and gas to flow from the formation into the well.

Pool
An individual accumulation of oil and gas. One or more pools may constitute a field.

Production Testing
Refers to a series of tests to determine the capacity of the well to produce oil and gas.

Production Well
A well drilled and completed in such a manner as to produce oil and gas without additional work in the hole.

Reservoir
Porous, permeable sedimentary rock structure or trap. A reservoir may contain more than one pool (accumulation of oil or gas).

Rigging up
Act of getting a rig assembled and ready to start drilling.

Rotary drilling
Method of drilling in which the drill pipe is rotated in order to rotate the bit.

Seismic Survey
Method of utilizing shock waves created by explosions or other means, to map the subsurface.

Seismograph
Instrument used for recording and timing the appearance of seismic waves; also used for measurement of earthquakes.

Shallow well
Term used to signifiy wells or drilling operations in formations known not to contain significant accumulations of hydrocarbons. Wells that have not reached the threshold depth are shallow wells.

Spud or spudding in
Commencement of the actual drilling of a well. (Sequence of events: rigging up, spudding, drilling ahead or making hole, reaching total depth, testing, completion.)

Stepout well
Well drilled seeking an extension of an oil or gas pool.

Stratigraphic trap
Subsurface geological condition that may create an accumulation of oil or gas through a change in character (porosity, permeability) in the hydrocarbon-bearing formation.

Surface casing
First string of casing set in well.

Testing tool
Piece of pipe that can be opened to the outside.

Threshold depth
The depth identified by geological and geophysical methods dividing the formation known not to contain significant accumulations of hydrocarbons. Wells that have not reached the threshold depths are shallow wells.

Trap
Any geological condition which acts as a barrier to the migration of oil or gas through subsurface rocks, causing them to accumulate into an oil or gas pool.

Tubing
Small diameter pipe through which oil and gas are produced for a well. It is run inside the casing and is generally two to four inches in diameter.

Well logging
Recording information about subsurface geologic formations; methods include records (logs) kept by the driller, mud and cuttings analysis, core analysis, electric and radioactivity procedures.

Wet gas
Natural gas containing liquid hydrocarbons.

Wildcat (see exploration well)
Well drilled in search of oil or gas pool in an unproven area.

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